

What is Claimed:

1 1. A system for emitting and detecting one or more terahertz
2 frequency electromagnetic pulses, the system comprising a single transceiver
3 device for both emitting and detecting the pulses.

1 2. The system of claim 1 wherein the single transceiver device
2 comprises an electro-optic crystal.

1 3. The system of claim 1 wherein the single transceiver device
2 comprises a photoconductive antenna.

1 4. The system of claim 1 further comprising:
2 an optical source and related optics for providing:

3 (a) a plurality of pump pulses to excite the transceiver to
4 emit a corresponding plurality of terahertz output pulses, and

5 (b) a plurality of probe pulses timed to illuminate the
6 transceiver simultaneously with a corresponding plurality of
7 reflected terahertz pulses;

8 a chopper for modulating the terahertz output pulses at a first
9 frequency and having a clock output;

10 an object which is illuminated by the modulated terahertz output
11 pulses and reflects the plurality of reflected terahertz pulses; and

12 a lock-in amplifier, having a reference input connected to the
13 chopper clock output and auto-locked to the first frequency, for receiving and
14 reducing noise in a plurality of electrical signals, each signal carrying
15 information proportional to a corresponding reflected terahertz pulse as detected
16 by the transceiver.

1 5. The system of claim 4 further comprising one or more
2 parabolic mirrors between the transceiver and the object.

1 6. The system of claim 4 wherein the transceiver is a
2 photoconductive antenna that produces the electrical signals received by the lock-
3 in amplifier, each electrical signal produced when a probe pulse and a reflected
4 terahertz pulse simultaneously illuminate the antenna.

1 7. The system of claim 6 wherein the system further comprises
2 a data processor for processing the noise-reduced output signal from the lock-in
3 amplifier.

1 8. The system of claim 7 wherein the data processor is adapted
2 to produce a tomographic image based upon a difference in time between the
3 reflected pulses from different layers of the object.

1 9. The system of claim 7 wherein the data processor is adapted
2 to produce an image based upon a peak amplitude of each of the reflected pulses.

1 10. The system of claim 6 wherein the transceiver is an electro-
2 optic crystal that reflects a plurality of modulated probe pulses, each modulated
3 probe pulse created when the probe pulse and reflected terahertz pulse
4 simultaneously illuminate the transceiver and the terahertz pulse modulates the
5 probe pulse, the system further comprising:

6 a photodetector for detecting the modulated, reflected probe pulses
7 and for generating the plurality of electrical signals received by the lock-in
8 amplifier, the electrical signals carrying information transmitted by the
9 modulated, reflected probe pulses.

1 11. The system of claim 10 wherein the system further
2 comprises a data processor for processing the noise-reduced output signal from
3 the lock-in amplifier.

1 12. The system of claim 11 wherein the data processor is
2 adapted to produce a tomographic image based upon a difference in time

3 between the reflected pulses from different layers of the object.

1 13. The system of claim 11 wherein the data processor is
2 adapted to produce an image based upon a peak amplitude of each of the
3 reflected pulses.

1 14. The system of claim 2 wherein the electro-optic crystal is
2 mounted to the end of an optical fiber.

1 15. The system of claim 14 wherein the optical fiber is a
2 polarization-preserved optical fiber.

1 16. The system of claim 15 wherein the electro-optical crystal
2 has a volume of less than about 1 mm³.

1 17. A method for emitting and detecting a terahertz frequency
2 electromagnetic pulse, the method comprising the step of:

3 (a) emitting and detecting the terahertz frequency pulses using a
4 single transceiver device.

1 18. The method of claim 17 further comprising the steps of:

2 (a1) exciting the transceiver device with a pump pulse to emit a
3 first terahertz frequency output pulse;

4 (a2) modulating the terahertz frequency output pulse with a
5 chopper;

6 (a3) illuminating an object with the modulated terahertz
7 frequency output pulse so that the object reflects a reflected terahertz pulse; and

8 (a4) illuminating the transceiver device with the reflected
9 terahertz pulse simultaneously as a probe pulse illuminates the transceiver
10 device, such that the transceiver device produces a first signal carrying
11 information from the reflected terahertz pulse.

1 19. The method of claim 18 wherein the transceiver device is an

2 electro-optic crystal, wherein step (a4) comprises the terahertz pulse modulating
3 the probe pulse in the electro-optic crystal and the electro-optic crystal reflecting
4 the modulated probe pulse from a back surface of the electro-optic crystal,
5 wherein the first signal comprises the reflected, modulated probe pulse, the
6 method further comprising:

7 (a5) detecting the reflected, modulated probe pulse with a
8 photodetector and converting the information to a second signal; and

9 (a6) reducing noise in the second signal with a lock-in amplifier
10 to produce a third, noise-reduced signal.

1 20. The method of claim 19 further comprising:

2 (a7) processing the third, noise-reduced signal with a data
3 processor.

1 21. The method of claim 20 wherein the object comprises a
2 plurality of layers, each layer a respective distance from the transceiver, the
3 method comprising generating a plurality of pump pulses, probe pulses, and
4 terahertz pulses such that the object reflects a plurality of reflected terahertz
5 pulses, each reflected pulse having a peak amplitude intensity, the method
6 further comprising:

7 (a8) using information related to the peak amplitude intensity to
8 generate an image of the object.

1 22. The method of claim 20 wherein the object comprises a
2 plurality of layers, each layer a respective distance from the transceiver, the
3 method comprising generating a plurality of pump pulses, probe pulses, and
4 terahertz pulses such that the object reflects a plurality of reflected terahertz
5 pulses, each reflected pulse having a peak amplitude timing, the timing
6 corresponding to the distance of the layer that reflected the pulse from the
7 transceiver, the method further comprising:

8 (a8) using information related to the peak amplitude timing to

9 generate an image of the object.

1 23. The method of claim 18 wherein the transceiver device is a
2 photoconductive antenna, wherein step (a4) comprises the terahertz pulse and the
3 probe pulse creating a current in the antenna comprising the first signal, the
4 method further comprising:

5 (a5) reducing noise in the first signal with a lock-in amplifier to
6 produce a second, noise-reduced signal.

1 24. The method of claim 23 further comprising:

2 (a6) processing the second, noise-reduced signal from the lock-in
3 amplifier with a data processor.

1 25. The method of claim 24 wherein the object comprises a
2 plurality of layers, each layer a respective distance from the transceiver, the
3 method comprising generating a plurality of pump pulses, probe pulses, and
4 terahertz pulses such that the object reflects a plurality of reflected terahertz
5 pulses, each reflected pulse having a peak amplitude intensity, the method
6 further comprising:

7 (a7) using information related to the peak amplitude intensity to
8 generate an image of the object.

1 26. The method of claim 24 wherein the object comprises a
2 plurality of layers, each layer a respective distance from the transceiver, the
3 method comprising generating a plurality of pump pulses, probe pulses, and
4 terahertz pulses such that the object reflects a plurality of reflected terahertz
5 pulses, each reflected pulse having a peak amplitude timing, the timing
6 corresponding to the distance of the layer that reflected the pulse from the
7 transceiver, the method further comprising:

8 (a7) using information related to the peak amplitude timing of the
9 reflected terahertz pulse to generate an image of the object.